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Abstract

The University of Waterloo is a major technical university in Canada, operating a co-operative education program for over 19,000 engineering and other applied sciences students. The co-op work terms are assigned to students using a priority matching mechanism (the Waterloo mechanism) of the type described in [Roth, 9]. I outline the stated design goals of the University for this matching mechanism, and present theoretical and empirical evidence that the Waterloo mechanism is failing both the students and employers it serves, as well as the goals of the University. I then propose an alternative matching mechanism based on the algorithm of [Gale and Shapley, 3], which I argue weakly improves on the Waterloo mechanism on each goal the University set out for its co-op matching mechanism. Finally, I consider a likely objection to such a mechanism, and conduct simulation studies to evaluate the force of such an objection, concluding that it does have some power and that the proposed mechanism requires further theoretical study.

1 Introduction

1.1 The University of Waterloo's JobMine

The Unviersity of Waterloo (UW) is a leading comprehensive research university in Waterloo, Canada, with over 30,000 undergraduate and 5,000 graduate students. It is well-known both in Canada and abroad for excellence in computer science, mathematics, engineering, and applied mathematics, and has a widely respected co-operative education (co-op) program in which 19,000 undergraduate students and 5,200 employers participate [7].

UW's co-op program combines academics with work experience, alternating academic terms with work terms approximately every four months. Over the course of five years, the co-op program gives students six work terms totalling 24 months of work experience before graduation, often in industries like engineering and technology due to UW's heavy STEM focus. These co-op terms are therefore highly important to a student's future employment prospects, and with almost four times as many students as employers in the system (though one employer may hire several students), competition is intense. As a result, UW created JobMine, a web application which allows employers to post job listings and students to search through these listings, as well as providing functionality for arranging interviews and viewing information on job offers.

Most importantly, JobMine also functions as a front-end to a matching algorithm between students and jobs. After students complete interviews with potential employers, both students and employers express their respective preferences for jobs to JobMine, and a matching mechanism is used to assign co-op terms to students. This matching mechanism, which I will refer to as the Waterloo mechanism, is described in detail below.

1.2 The Waterloo Mechanism

The Waterloo mechanism proceeds as a phase of preference revelation, followed by a phase of matching.

1.2.1 Preference Revelation

After all student-employer interviews have been conducted, employers are asked to assign every student they interviewed either

1. a numerical rank from 1 to 9, or
2. a status of No Rank (NR).

For any particular position that employers are looking to fill, employers may only rank a single student with the rank of 1, but may rank multiple students with the ranks of 2 through 9 [6].

Once all employers complete their rankings, students are informed, for each of the jobs they interviewed, whether they

1. received an offer (assigned a rank of 1 by the employer),
2. received a rank (assigned a rank of 2 through 9 by the employer), or
3. were not ranked (assigned NR by the employer).

Note that a student, if ranked, only sees that he or she was ranked, and not the numerical rank from 2 to 9 that the employer actually assigned. Students then rank each job for which they received an offer or a rank with a numerical value between 1 and 9. Students may rank as many jobs with any particular numerical value as they wish. This concludes the preference revelation stage of the Waterloo mechanism [5].

1.2.2 The Rank-Sum Mechanism

With preferences stated, JobMine proceeds to create co-op matches between students and jobs. In particular, for each student-job pair in which the student received either an offer or a rank, the sum of the employer's rank of the student for the job and the student's rank of the job (the rank-sum) is computed. Student-job pairs are assigned in order of increasing rank-sum, and ties are broken randomly [5].

Example 1.1. Consider a simple instance of the rank-sum mechanism, matching three students $\{s_i\}_{i=1,2,3}$ to three jobs $\{j_i\}_{i=1,2,3}$. The preferences of the students and jobs with respect to each other are summarized the following table.

Table 1: Simple Preferences and Corresponding Rank-Sums

	j_1	j_2	j_3		j_1	j_2	j_3
s_1	1,1	3,1	2,1	s_1	2	4	3
s_2	2,3	1,2	3,2	s_2	5	3	5
s_3	2,2	1,3	3,3	s_3	4	4	6

The (m, n)th entry of the left table contains a tuple (a, b) where a is s_m's ranking of j_n and b is j_n's ranking of s_m. The (m, n)th entry of the right table contains the rank-sum of the $s_m - j_n$ student-job pair. The rank-sum mechanism would first match (s_1, j_1). Then, it would match (s_2, j_2), and finally (s_3, j_3) would be the only possible pair remaining and thus would be also be matched.

Note that in the rank-sum mechanism, any pair that mutually ranks each other as their first choice is guaranteed to be matched.

The rank-sum mechanism is an example of a priority matching mechanism of the type studied in [Roth, 9]. In particular, priority matching mechanisms determine matches by assigning a priority to each particular pair to be matched, and making matches in order of ascending or descending priority. Roth describes a rank-product priority structure, as well as a lexicographic priority structure in which $(1, 1)$ matches are made first, followed by $(1, 2)$, $(1, 3)$, and so on in the residency matches of Newcastle, Birmingham, and Edinburgh in the 1960s. To the best of my knowledge, a rank-sum priority structure as not been explored before in the literature.

Roth notes that priority matching mechanisms can induce unstable matchings, and that it is never a dominant strategy for any agent to submit her true preferences in any priority matching mechanism. These well-known theoretical observations will inform our analysis of the success of JobMine in the next section.

2 Design In Theory and In Practice

In this section, I explore the design goals of UW's JobMine and the features it was meant to have, as well as whether these features are actually induced by JobMine in practice.

2.1 Design Goals

The key principles around which JobMine was designed intended

1. to allow students to get the jobs they wanted, and for employers to get the students they wanted,
2. to prevent opportunities for students to game the system, and
3. to balance student and employer interests [14].

The first criterion can be formalized as a notion of *efficiency*: UW hopes, through the Waterloo mechanism, to provide the best possible outcomes for students and employers.

The second criterion is well-known in the market design literature as *strategy-proofness*. A strategy-proof matching mechanism is such that the dominant strategy of any agent in the mechanism is to state their true preferences (therefore, it would be impossible for an agent to "game" the system).

The final criterion is one that has not appeared before in the market design literature, and is what I will call in this paper *balance*. Though not yet formalized, the notion of balance hints at the idea that students and employers should have equal influence on the outcomes of the matching mechanism, so that employers or students do not have undue sway over their matches.

Several idiosyncratic aspects of the Waterloo mechanism were designed around these principles. In particular, summing the ranks of students and employers was intended to speak to the idea of balance—the ordinal preferences of students and employers intuitively have equal weight when they are summed. Furthermore, the ability for students to see which employers had ranked them with a 1 was intended to speak to the idea of efficiency. Since any pair with a rank-sum of 2 is guaranteed to be matched, students are able to create their highest-quality matches with employers who also want them.

Though these design elements intuitively seem to support the principles that UW hopes to pursue, I now present some evidence that JobMine may not in practice be performing as its designers intended.

2.2 Implementation Issues

Interviews with current UW students and evidence collected from various online forums suggests that JobMine is failing to satisfy the three principles it was designed around. From

UW's Reddit subforum, we find evidence contrary to the idea that high quality and efficient student-job matches are being made [11]. For instance, a student posted,

> I have an offer at company A, ranked for company B, I prefer B over A. Some people told me that if I rank A as 2 and B as 1, I am still guaranteed a job AND have a chance at B, but I'm scared to end up jobless if I do that as the jobmine [sic] site said "random" if there are 2 candidates with the same sum. Help?

Several days later, the student follows by by stating "Update: I ended up playing it safe and ranked my offer 1", taking a safe option over her most preferred option. As with other priority-based mechanisms, it seems that the Waterloo mechanism may produce observed matches at low ranks which do not reflect the actual welfare of students and employers.

A significant proportion of the posts on the UW Reddit subforum also revolve around ranking advice and detailed attempts to strategize. For instance, a Reddit user [13] posted

> I was hoping to get some advice for how I should rank my jobs/offers on JobMine [...] Company A is the most desirable but they've only ranked me. Company B is the second most desirable and I have an offer from them. Companies C and D, I don't really want, but I have offers from them. I plan to rank them as follows: A 1 B ??? (somewhere between 3 and 7) C 9 D 9 and all the other ranks as 9 as well. I was hoping to get some advice as to how I should rank company B, and if this ranking I have currently is safe and gives me the best possible chances of getting company A.

These detailed attempts to strategize confirm the theoretical observation that priority matching mechanisms are not strategy-proof. Furthermore, a general perception exists among students that the JobMine algorithm favors employers, with rumors abounding that employer preferences are weighted more heavily in the matching algorithm. Thus, the efficiency, strategy-proofness, and balance of the JobMine system at UW appears to be in question. Finally, there is anecdotal evidence that employers are increasingly directly calling students to inform them of an exploding offer (an offer that, if the student does not accept it within a certain timeframe, expires), bypassing the JobMine system entirely.

Perhaps the most succinct summary of the current state of JobMine comes from a response to the author's post on the UW Reddit inquiring into whether students were aware of the origins and design goals of JobMine: the top-voted comment (from a presumptive student) was that "the primary goal of jobmine [sic] is to cause anxiety, pain, and suffering" [12].

3 Incompatibility of Design Goals

In this section, I will present theoretical results relating to the Nash equilibria of a stylized version of the Waterloo mechanism I proved in a previous class, and make some further conjectures for which proofs are still unavailable.

3.1 Previous Results

The theoretical results in this subsection were proven by me for a previous class, and are stated to put the conjectures and results stated below in context.

I consider a stylized version of the Waterloo mechanism for a one-to-one matching market of students S and employers E, where students and employers have known, strict, and complete ordinal preferences P and Q respectively over each other, and $|S| = |E| \coloneqq N$. I assume that the preference revelation game is one in which students and employers must submit strict and complete ordinal preferences over each other (e.g. students cannot assign a rank of 1 to more than one employer), and I abstract from the feature of the Waterloo mechanism allows students to see employer rankings before they submit their own. Matches are sitll made in order of increasing rank-sum. This setup strips the Waterloo mechanism down to its essence: the rank-sum mechanism.

Since the rank-sum mechanism produces potentially random outcomes (ties in rank-sum are broken randomly), I define a random matching as a random variable $\tilde{\mu} : \Omega \to M$ which realizes a value in the space of matchings M, where a matching $\mu \in M$ is a bijective function $\mu : S \to E$ from the set of students to the set of employers. We refer to a random matching as a deterministic matching if the random matching realizes a particular matching with probability 1.

Since the outcomes of the rank-sum mechanism are random matchings, we must define an ordering on random matchings with which agents can use to express preferences over their potential outcomes. We say a strategy profile $\mathbb{P}$ is an ordinal and strict preference ordering submitted by an agent in a preference revelation game, which may or may not be the same as the agent's true preferences.

Definition 3.1. A reasonable stochastic P_s-ordering $\rhd_{P_s}$ is an ordering over random matches which has its ordering over deterministic matches induced by P_s, and satisfies $\tilde{\mu}_i \rhd_{P_s} \bar{\tilde{\mu}}_{j\leq i}$ where $\tilde{\mu}_i$ deterministically matches s to her ith most favored choice under P_s and $\bar{\tilde{\mu}}_{j\leq i}$ matches s to her jth most favored match under P_s for $j \leq i$ with equal probability.

A random matching $\tilde{\mu}$ stochastically P_s-dominates a random matching $\tilde{\nu}$ in a reasonable way if $\tilde{\mu} \rhd_{P_s} \tilde{\nu}$ for any reasonable stochastic P_s -ordering $\rhd_{P_s}$.

A strategy profile $\mathbb{P}_s$ stochastically P_s-dominates another strategy $\mathbb{P}_s^{'}$ if for any true preferences (P, Q) and any strategy profile $(\mathbb{P}_{-s}, \mathbb{Q})$, the resulting random matching of $(\mathbb{P}_{-s}, \mathbb{P}_s, \mathbb{Q})$ stochastically P_s-dominates $(\mathbb{P}_{-s}, \mathbb{P}_s^{'}, \mathbb{Q})$ in a reasonable way.

Intuitively, a reasonable stochastic P_s-ordering is an ordering over random matches in which any deterministic matches are ordered by P_s, and a deterministic matching to any particular choice is preferred over being matched to any weakly less preferred choice with equal probability. This definition encompasses a range of potential orderings over random variables, including the well-known notion of first-order stochastic P_s-dominance.

When a random matching stochastically dominates another random matching in a reasonable way, under every reasonable stochastic ordering, an agent will prefer the former random matching. Finally, when a strategy profile stochastically dominates another strategy, for any true preferences, an agent will prefer the outcome under the former under any reasonable stochastic ordering.

These definitions give us a language to compare the random outcomes of the Waterloo mechanism. I now present two of my previously derived results.

Proposition 3.1. *There is no stochastically dominant strategy for any agent in the preference revelation game induced by the rank-sum mechanism.*

This proposition says that regardless of the true preferences of students and employers, no agent will always choose to play the same strategy regardless of the strategies of other agents. As such, the rank-sum mechanism is obviously not strategy-proof. Intuitively, the result comes about because each agent in the preference revelation game has a high level of influence over the outcome of the game (since matches are determined in order of rank-sum, both students and employers can influence the matches strongly, and to equal magnitude, by lying about their preferences).

Proposition 3.2. *For any true preferences, the set of possible deterministic matchings under the rank-sum mechanism is a weak subset of the set of outcomes induced by the Nash equilibrium strategies of the preference revelation game.*

This is damning result that says that regardless of the true preferences of students and employers, every possible matching between students and employers is possible in Nash equilibrium. In some sense, the rank-sum mechanism is essentially useless, since it is possible to get any outcome in equilibrium.

This result is a product of the first proposition. Since no agent has a dominant strategy, each agent in the preference revelation game has a huge number of degrees of freedom with which to modify her strategy profile. Combined with the fact that any $(1, 1)$ mutual ranking guarantees a match being made, agents are able to, in this giant coordination game, be assigned any outcome in equilibrium.

3.2 Some Conjectures

I now make some conjectures and remarks, guided by intuition and the proofs for the above results.

Conjecture 3.1. *The propositions above hold when the idiosyncratic elements of the Waterloo mechanism are re-introduced.*

In the above setup, I abstracted from the fact that in the real Waterloo mechanism, students and employers may assign more than one employer or student respectively to a particular rank (with the exception that employers can only assign one student to rank 1), and the fact that students can view employer rankings before submitting their own rankings. Both these design elements intuitively seem to contribute to the problem of degrees of freedom: With many students or employers at the same rank, the coordination game just becomes even larger, and students being able to view employer rankings would allow them to strategize even more than in the model above. As such, the proposed model seems to be a parsimonious and flattering view of the Waterloo mechanism.

Remark 3.1. The two-sided Boston mechanism is likely unbalanced, which leads to the equivalence of stable matchings and Nash equilibrium outcomes.

[Ergin and Sonmez, 2] show that all stable matchings are Nash equilibrium outcomes under the preference revelation game induced by the two-sided Boston mechanism. The two-sided Boston mechanism has truthtelling as a dominant strategy for schools, which prevents the huge number of degrees of freedom that appear in the rank-sum mechanism and that allow for the expression of any deterministic outcome in equilibrium under the rank-sum mechanism. The existence of a dominant strategy is intuitively a result of the two-sided Boston mechanism giving students more say than schools, in the sense that the preferences of schools are only considered within the stratified tiers of student preferences. Though we have not formalized a notion of balance, it seems intuitive that the two-sided Boston mechanism is fundamentally less balanced than the rank-sum mechanism, and this imbalancedness admits a dominant strategy for one side, and a restriction of the possible outcomes in Nash equilibrium.

Conjecture 3.2. *There is no efficient, strategy-proof, and balanced two-sided matching mechanism.*

[Zhou, 15] showed that there is no Pareto efficient, strategy-proof, and symmetric one-sided mathcing mechanism, where symmetry is defined to be the property under which the equivalence of preferences for two agents implies equivalence of outcomes. In other words, a one-sided mechanism is symmetric if agents can only distinguished by their preferences. This is a tantalizingly close result to the conjecture I make. Drawing on the intuition from the previous remark, it seems that the notion of balance, or giving all agents equal say in outcomes is incompatible with the existence of dominant strategies required to limit the possible outcomes induced by a preference revelation game.

If this conjecture, or some variant of it, is true, then UW has a problem on their hands: Their three goals are fundamentally incompatible. The propositions already proven suggest that JobMine in its current state simply does not work, and empirical studies of student responses to JobMine seem to support these results. But the intuitions I present in this subsection suggest that the mission of JobMine may have been fundamentally misguided from the outset. If Conjecture 3.2 is true, UW must decide which of the three principles it is willing to give up (or at least willing to give up to some extent). In the next section, I present a proposal, which though not yet supported by a rigorous mathematical foundation, seems to offer a potential compromise between the goals of efficiency, strategy-proofness, and balance.

4 A Proposal

4.1 A New Waterloo Mechanism

In this subsection, I propose an alternative matching algorithm for UW's JobMine, which tries to balance (pun not intended) UW's goals of efficiency, strategy-proofness, and balance.

[Gale and Shapley, 3] proposed the seminal Gale-Shapley algorithm in 1962, which matches students to jobs in a two-sided market deterministically. This matching mechanism produces stable matchings, where a match is stable if there is no student [employer] that prefers a different employer [student] to her current partner, and that employer [student] also reciprocates by preferring the student [employer] over her current partner.

The Gale-Shapley algorithm can be implemented in a student-optimal or employer-optimal way. The student[employer]-optimal algorithm produces a stable match in which each student [employer] has the best partner that she can have in any stable match.

My proposal for a new Waterloo mechanism is as follows: The preference revelation stage should be replaced by a simpler game, in which students and employers who interviewed with each other rank each other strictly and ordinally. Not all students interview with all employers, so any employer that a student did not interview with is assumed to be less preferred than no match for that student.

The matching stage, instead of a rank-sum mechanism, will use a student-optimal or employer-optimal Gale-Shapley algorithm, chosen with equal probability at the start of each co-op term. I will call this mechanism the random-optimal Gale-Shapley mechanism (RGS).

4.2 Compromising Between Goals

As discussed above, it seems not entirely unreasonable that the three goals of efficiency, strategy-proofness, and balance that UW has outlined JobMine cannot be achieved simultaneously. I argue in this subsection that RGS offers a compromise between these three goals, and has additional features that may be considered desirable to UW. Furthermore, I point out that the current rank-sum mechanism hardly satisfies these goals to begin with, and that RGS is a weak improvement along each of these axes.

Stability Any realized outcome of RGS is stable. Stability is desirable in general because no matches will be willfully broken: There are no students [employers] who are able to find another employer [student] who is happy to switch partners with them. Though this was not a design goal of Waterloo's, it seems like UW should be happy to have a stable mechanism. This is in particular true because students have reported some level of unraveling, where employers directly contact students to give them job offers and bypass the JobMine system completely (a well-known result of unstable mechanisms [Halaburda, 4]). UW has stated that they would like JobMine to be a centralized system for the co-op program, and thus have indirectly stated the need for a stable mechanism.

Efficiency From an efficiency standpoint, the Gale-Shapley algorithm is of interest because it is the stable mechanism that Pareto dominates any other mechanism which eliminates justified envy i.e. no student [employer] prefers the partner of another student [employer] when that partner prefers the former student to her current partner [Abdulkadiroglu and Sönmez, 1]. In some sense then, the student[employer]-optimal Gale-Shapley algorithm is as efficient as a matching mechanism can be for students [employers] while maintaing stability and eliminating justified envy. So, ex-post, RGS produces the most efficient stable outcomes in which either participants will not justifiably envy each other (a welcome property in a tight-knit school like UW). There is also no substantial evidence that the rank-sum mechanism is particularly efficient, especially since the actual matches made do not reflect the true preferences of the participants (and, empirically, it seems that students are often forgoing their top choices in order to rank the employers "safely").

Strategy-proofness The student[employer]-optimal Gale-Shapley algorithm induces a dominant strategy for students [employers] to state their true preferences, i.e. is strategy-proof for students [employers]. However, there is no stable mechanism for which truth-telling is a dominant strategy for both sides, as [Roth, 8] showed. This being said, there is some simulation evidence that the chances an employer [student] benefits from strategic preference submission in the student[employer]-optimal Gale-Shapley algorithm is slim [Teo et al., 10]. So, we can understand the student[employer]-optimal Gale-Shapley algorithm as being strategy-proof for students [employers] and "almost" strategy-proof for employers [students]. Then, RGS is likely "almost" strategy-proof for both students and employers (though this needs a formal proof), unlike the rank-sum mechanism which is obviously and extremely vulnerable to manipulation.

Balance Though we have not yet formalized a notion of balance, it seems intuitively clear that RGS is at least as balanced as the rank-sum mechanism, since it assigns a student[employer]-optimal match with equal probability. There seems to be no way in which students or employers have more say in this system.

4.3 Ex-Post Balancedness

The primary objection I anticipate to RGS is the worry that ex-post, the matching is either optimal for students or for employers. While this is unavoidable, simulation studies that compare how "different" the student-optimal and employer-optimal matches may be can be useful for understanding how much force this objection holds. First, I study the relationship between the number of participants in the market and the minimum number of partner swaps needed to transform the student-optimal match into the employer optimal match (this is an intuitive notion of distance between matches). I simulate 1000 random sets of preferences for a market of N students and N employers, and compute the minimum number of partner swaps needed to transform the student-optimal match into the employer-optimal match i.e. the Cayley distance, reporting the normalized distance (the minimum number of swaps divided by the maximum possible Cayley distance of a list of length N, which is equal to $N-1$) below.

The results in Table 2 are slightly disheartening; we see that as N grows, the student- and employer-optimal matches become farther and farther away from each in other in the space of possible matches, and with $19,000$ students and $6,000$ employers in the JobMine system, it seems that the optimal matches for students and employers would be extremely far from each other in match space. Intuitively, this is a result of long preference orderings which allow for student-optimal matches to look very different than employer-optimal matches. This is undesirable, even though RGS is balanced ex-ante, since ex-post of the coin flip to choose a student- or employer-optimal scheme, students or employers may feel like the realized outcomes favor the other party. However, in practice, even though there are many students and employers, any particular students interviews with a relatively small number of employers, and vice versa; it is possible that the effective N in the real world may be smaller than it would initially seem.

Furthermore, in practice, student and employer preferences are not random, and we expect them to display some degree of correlation. To simulate this, I consider 1000 simulations in which student [employer] preferences are completely random, and where preferences are $b-$block correlated (the set of the first, second, third, and so on N/b preferences for each student [employer] are the same, but the order within each N/b block of employers [students]

Table 2: Distance between student- and employer-optimal matches with N students and N employers

N	Expected normalized distance
5	0.80
10	0.86
50	0.94
100	0.96

Table 3: Effects of correlated preferences on optimal match distance with $N = 50$

Preference correlation	Expected normalized distance
Uncorrelated	0.94
2-block correlated	0.90
5-block correlated	0.79
10-block correlated	0.65

is random).

From Table 3, it appears that the more correlated preferences are, the smaller the distance between the student- and employer-optimal matches. This is encouraging, since preferences in real life are almost certainly correlated (many students want to work at Google or Facebook, and many different companies want to hire top students). In particular, many students are likely interviewing with the same top companies, and their preferences among these top companies are likely fairly similar.

Ultimately, even with a fairly small N and somewhat strongly correlated preferences, the expected normalized distance is still fairly high. This is somewhat discouraging for the balancedness of the ex-post outcomes of RGS, suggesting that the matches made under student-optimal Gale-Shapley are fairly different from the ones made under employer-optimal Gale-Shapley (one can imagine this would be a source of discontent if the non-optimal side for a particular realization of this mechanism is unhappy with their matches). One practical way to minimize this discontent is to not reveal whether the instance of RGS for a particular co-op matching was student- or employer-optimal, and make a credible claim that the choice of side for optimality is indeed a fair and random choice.

5 Coda

5.1 Conclusion

In this paper, I outlined the University of Waterloo's JobMine system for assigning co-operative education work terms to the 19,000 engineering, math, computer science, and technical students at UW. I explored the design goals of the JobMine system and its failures in practice. I then presented previously derived theoretical results, which in combination with empirical interviews of current UW students, which suggest that the JobMine system is currently failing both the students who rely on it and the University's goals in implementing it. I proposed a new matching mechanism for JobMine, which seems to weakly improve on the current rank-sum mechanism along every design goal that UW outlined in addition to providing ex-post stable outcomes. Finally, I conducted some simulation studies to evaluate the force of the most likely objection to the proposed mechanism, demonstrating that such an objection is rooted in some truth.

5.2 Next Steps

In terms of theory, outlining a formalization of the notion of balance is key to prove the conjecture that a two-sided matching mechanism cannot be efficient, strategy-proof, and balanced simultaneously. Proving the two conjectures stated above, which are related to the rank-sum mechanism, is another clear next step.

The proposed RGS mechanism is also in need of formal study. A characterization of the dominant strategies in the preference revelation game induced by RGS is of great need, and after a formalization of balance is acquired, showing that RGS is balanced would also be desirable. More study of the empirical performance of RGS, especially in realistic conditions mirroring the actual Waterloo co-op market (for instance, with students only interviewing with a small group of employers), will also help give the proposal force. The problem of ex-post balancedness (perhaps formally a different notion than ex-ante balancedness) must also be addressed if RGS is to be seriously considered as a replacement for the Waterloo mechanism: the feeling of being cheated when the other side is picked at random to be matched optimally may be a fatal flaw for RGS, if the student- and employer-optimal matches are indeed very different.

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